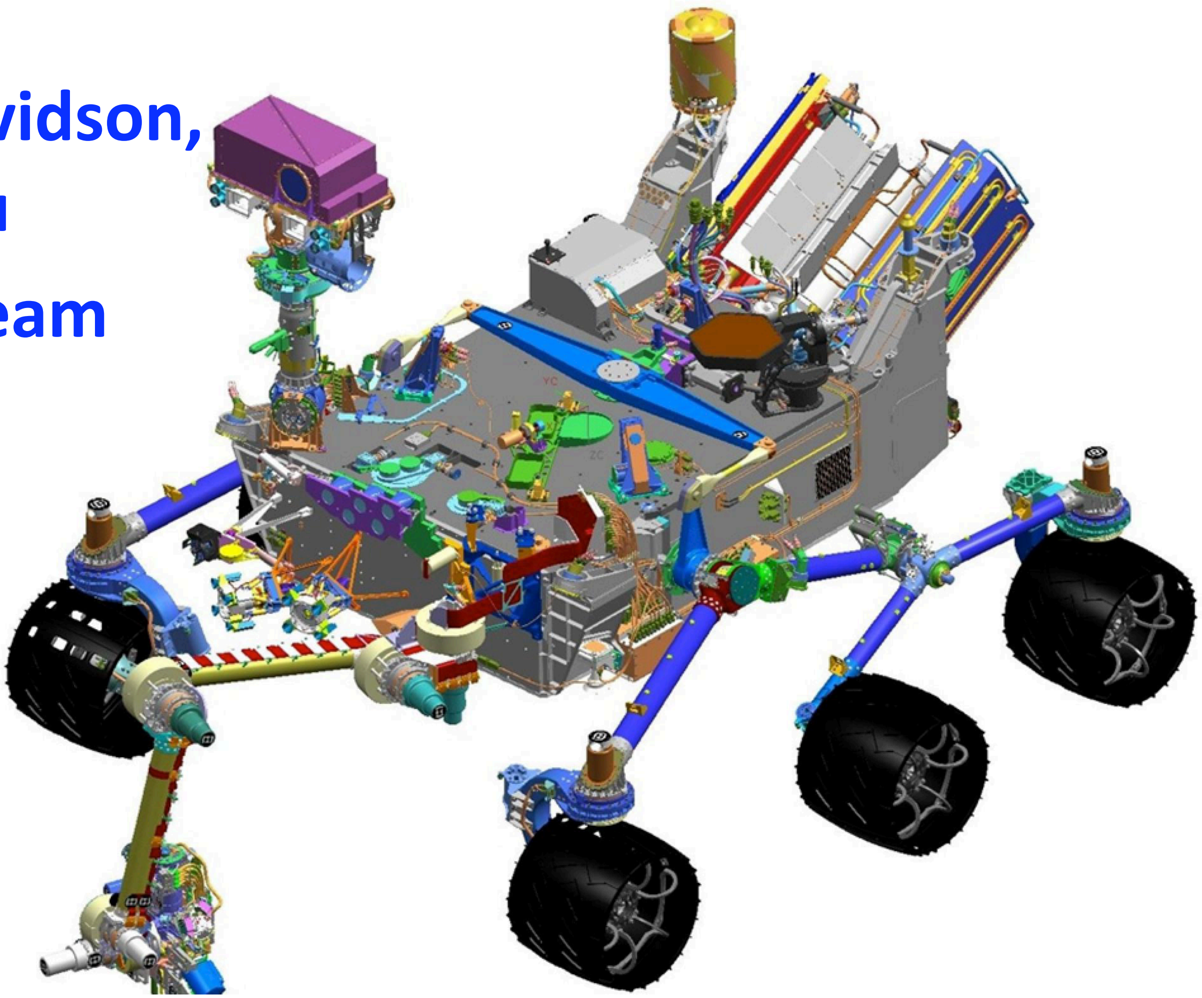
Science Objectives that can be Addressed by Experiments on MSL at Mawrth Vallis

Janice Bishop, Ray Arvidson, Damien Loizeau

and the Mawrth Team



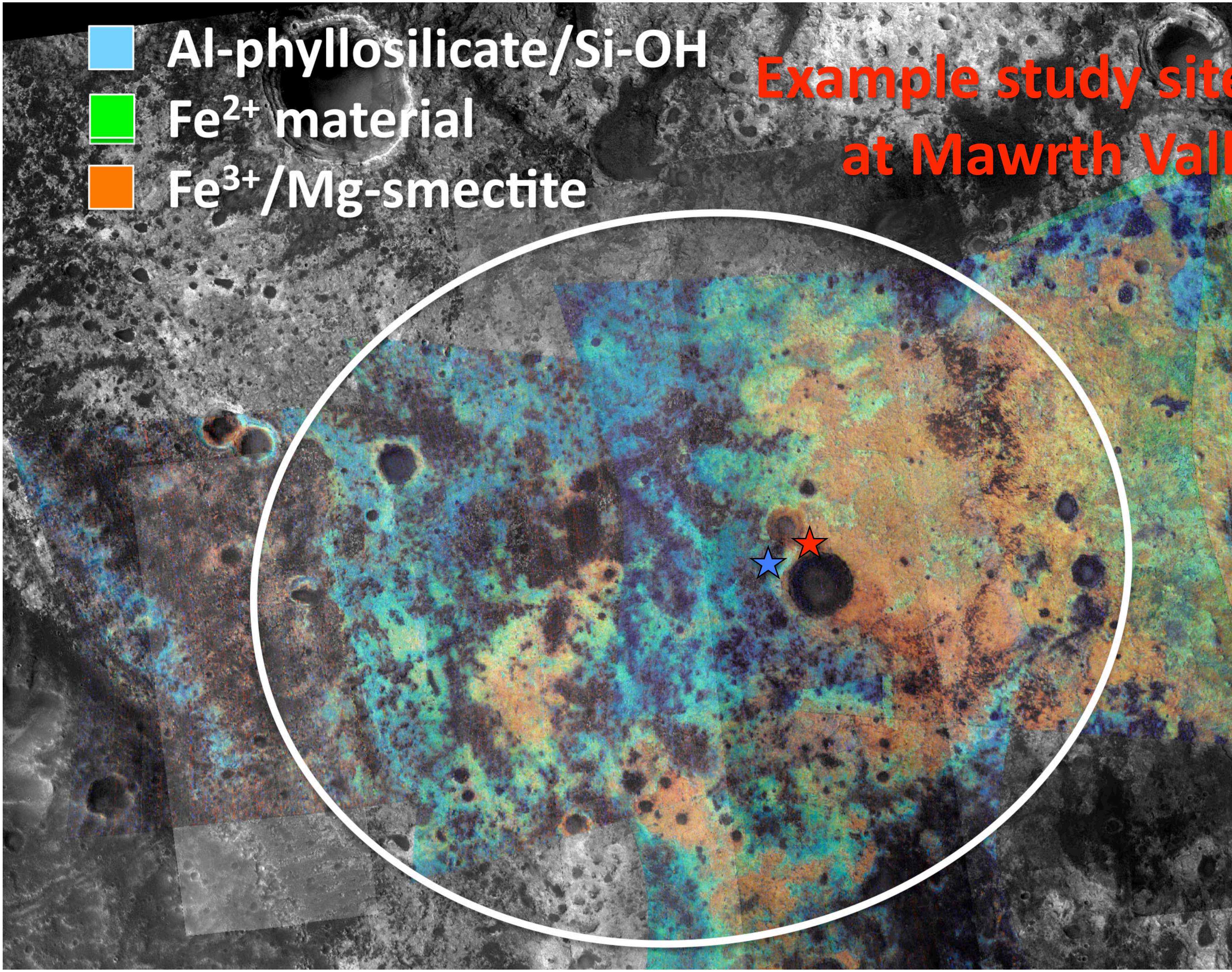
Example measurements and observations to be performed in order to meet MSL science objectives.

MSL Science Objectives

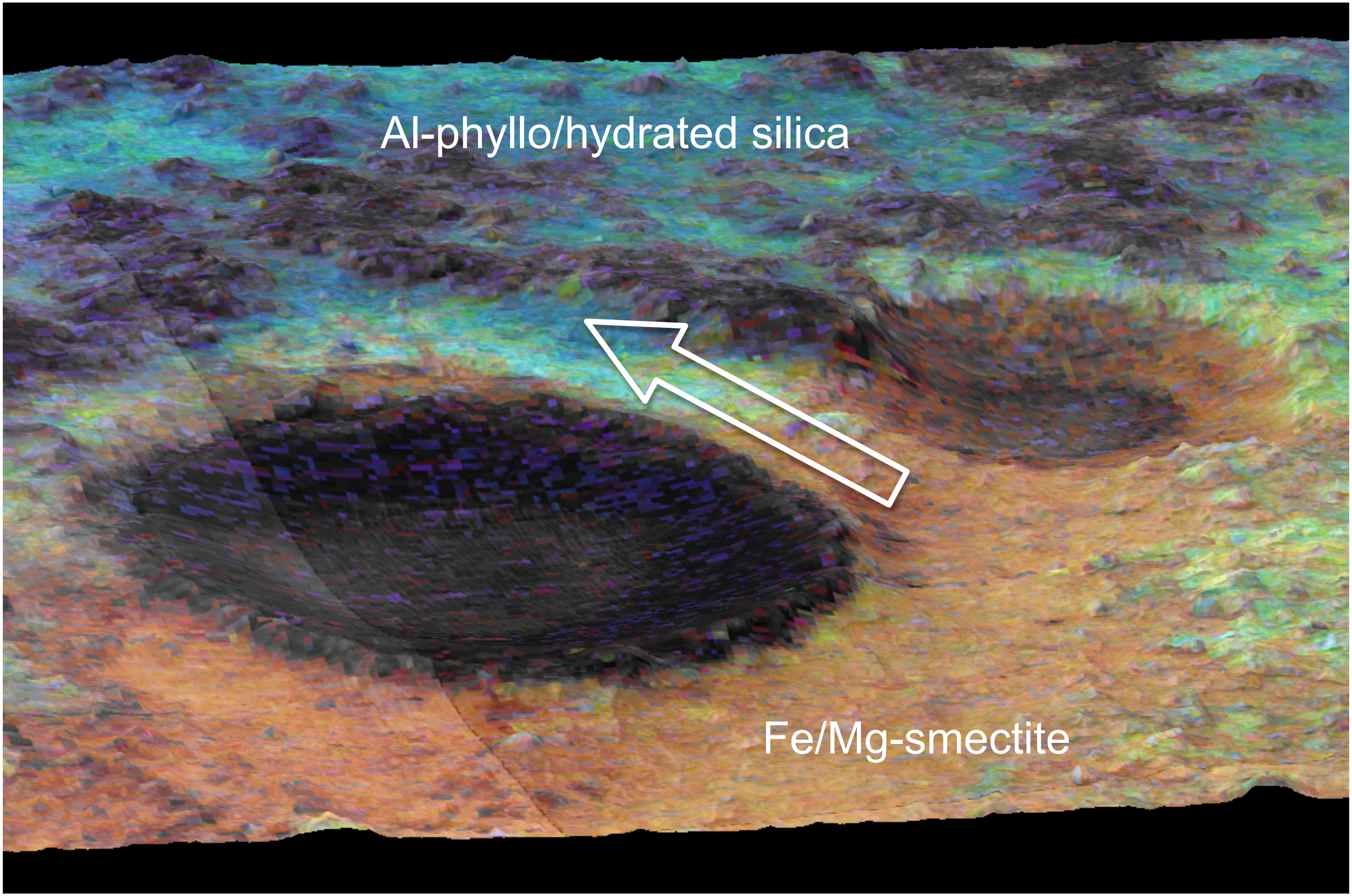
1. GEOLOGY	-characterizing geological features, deciphering geological history and processes that formed or modified bedrock and regolith, understanding role of aqueous processes.
2. MIN+CHEM	-determining mineralogy and chemical composition (including biologically important elements C, H, N, O, P, S) of surface and near-surface materials.
3. ORGANICS	-characterizing organic compounds and potential biomarkers in bedrock and regolith.
4. ATM	-determining stable isotopic and noble gas composition of current bulk atmosphere.
5. BIOSIGNATURES	-identifying potential biosignatures (chemical, textural, isotopic) in rocks and regolith.
6. PRESERVATION	-determining processes that could have preserved biosignatures and/or environmental history.
7. RADIATION	-characterizing surface radiation: galactic cosmic radiation, solar proton events, and secondary neutrons.
8. WEATHER	-characterizing local environment: basic meteorology, state and cycling of H_2O and CO_2, and near-surface H distribution.

MSL Experiments at Mawrth Vallis

- Mawrth Vallis experienced a long-term aqueous event(s) that inspired an intense, chemically changing and complex water-rock history likely to have supported a habitable environment.
  - MSL will be able to investigate small amounts of biogenic minerals, trapped gases, and isotopic signatures sequestered in the phyllosilicate-rich rocks.
- Test hypotheses built from analyses of OMEGA, CRISM, HiRISE and HRSC data about mineralogy and stratigraphy.
- Evaluate transition from ancient Fe/Mg-smectite-rich rocks to younger Al-phyllosilicate/hydrated silica-bearing rocks.
- Determine missing parts of story:
  - What is the remaining rock mineralogy (besides clays)?
  - What is "Fe^{2+}" component in between dominant clay units?
  - Are sedimentary features present in rocks?
  - How did phyllosilicate-rich rocks form?
  - Where did the water come from?
- Outline example experiments to be performed by MSL.

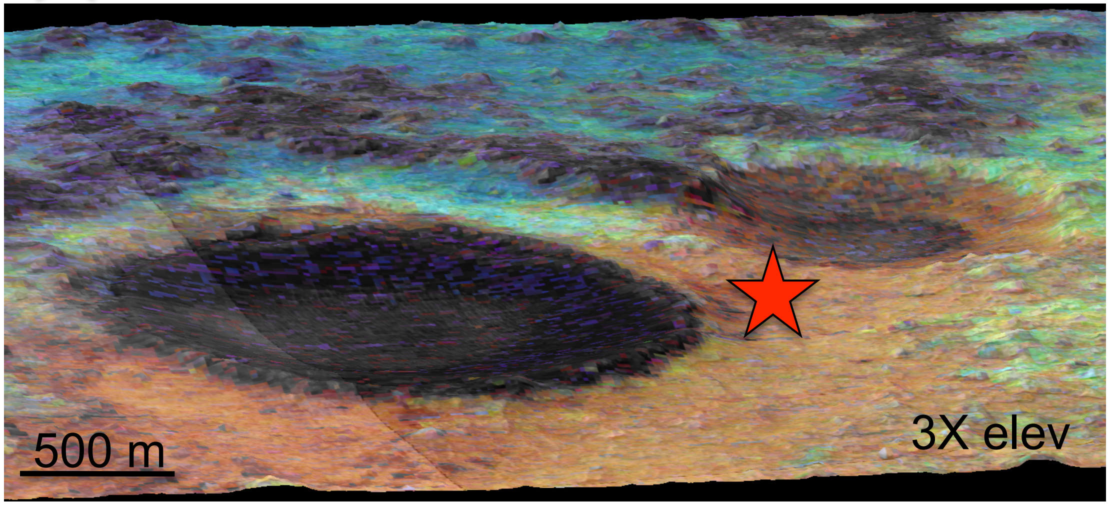


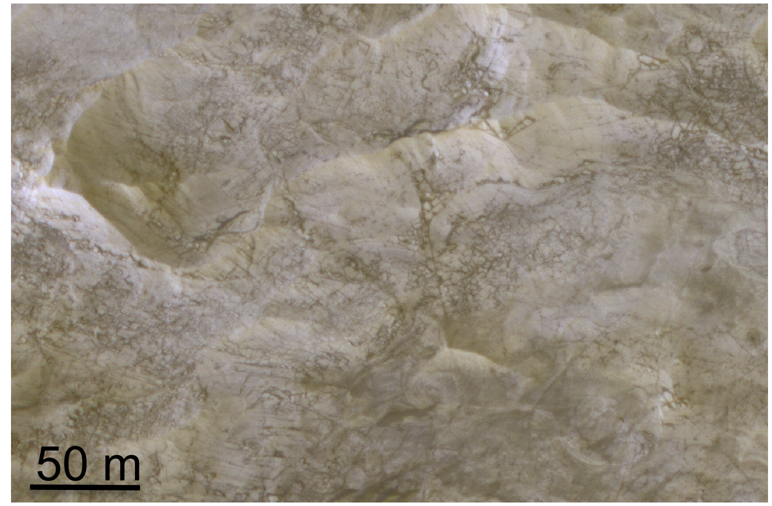
Al-phyllosilicate/Si-OH
Fe2+ material
Fe3+/Mg-smectite
Example study sites
at Mawrth Vallis



CRISM parameters over HiRISE DEM with 3X vertical exaggeration

Stop 1: Characterize Fe/Mg-smectite-rich rocks





1. GEOLOGY Image site with **Mastcam** to characterize morphology of Fe/Mg-smectite-rich rocks; look for layering indicative of aqueous processes; compare relative ages of Fe/Mg-smectite-rich rocks with material containing Fe^{2+} spectral slope; evaluate grain sizes of rocks in discreet units with **MAHLI**.

2. MIN+CHEM Confirm Fe/Mg-smectite mineralogy using **ChemCam**, **CheMin**, and **APXS**; determine if mineralogy is homogeneous or mixture at rover scale; estimate Fe/Mg-smectite abundance (30-60%); discover remaining 40-70% composition of the rocks; characterize C, H, N, O, P, S in clay-rich rocks using **SAM/APXS**; examine differences in mineralogy and chemistry from Fe/Mg-smectite-rich rocks and rocks containing Fe^{2+} material in order to assess changes in geochemical environment.

3. ORGANICS Identify any trapped organic compounds in smectites with **SAM** (note that Fe-rich clays are thought to have formed on early Earth and that they are likely to have trapped organics and facilitated organic reactions).

4. ATM Measure diurnal and seasonal atmospheric changes with **SAM** to look for surface/atmosphere interactions, e.g. production of methane.

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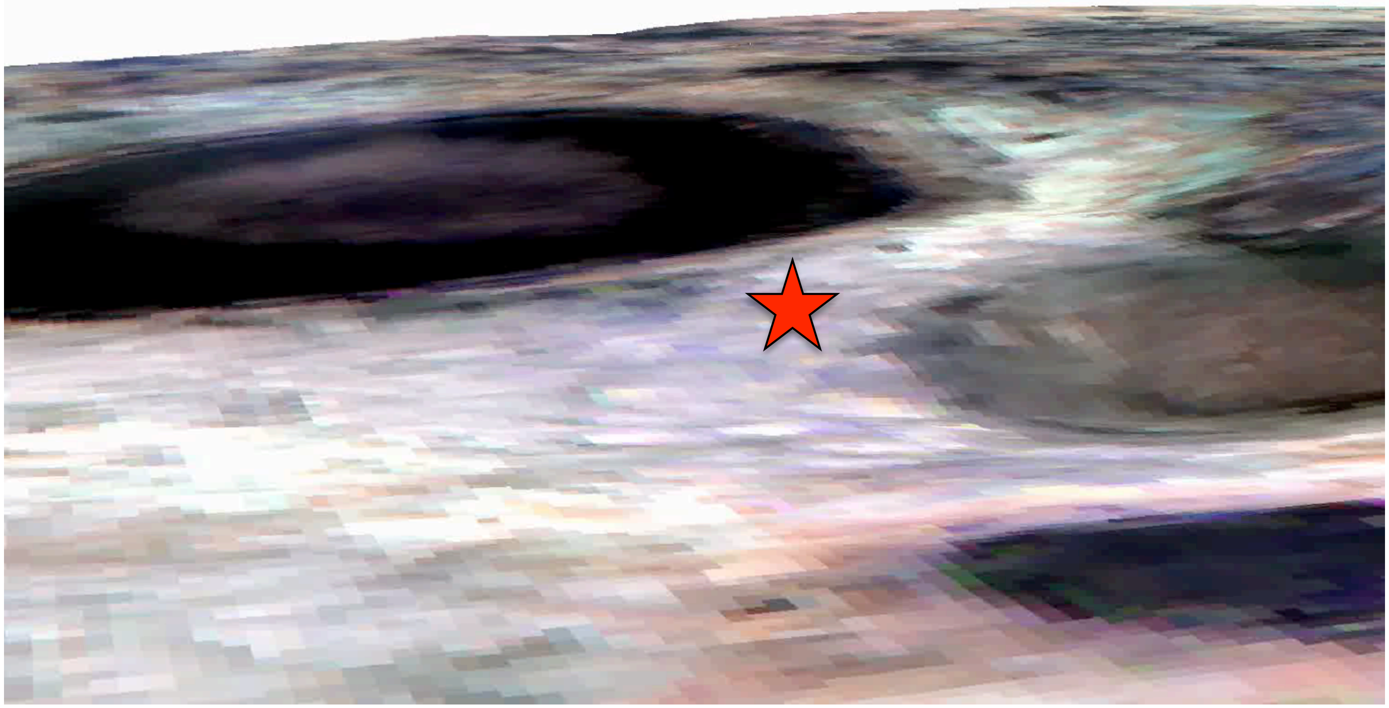

5. BIOSIGNATURES Characterize grain shapes and colors with **MAHLI**. Search for organics in smectites with **SAM** and look for isotopic shift in C & O with **SAM** that is expected if life were present.

6. PRESERVATION Search for evidence of sedimentary processes using **MAHLI** and minerals such as phyllosilicates and silica using **CheMin** and **APXS**. Look for evidence of impact or disruption that could have interfered with preservation.

7. RADIATION Measure surface radiation with **RAD** and **REMS**.

8. WEATHER Characterize meteorology, and H_2O and CO_2 cycling with **REMS**, and near-surface H using **DAN**.

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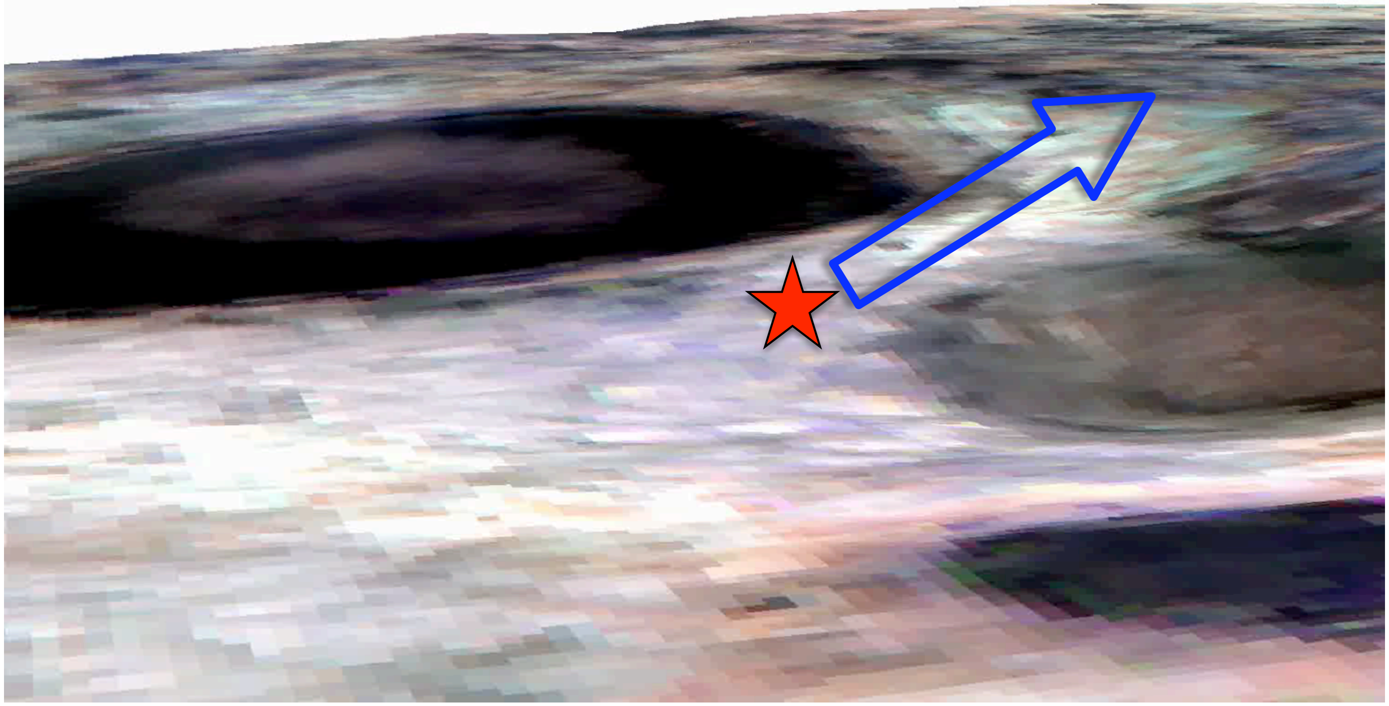

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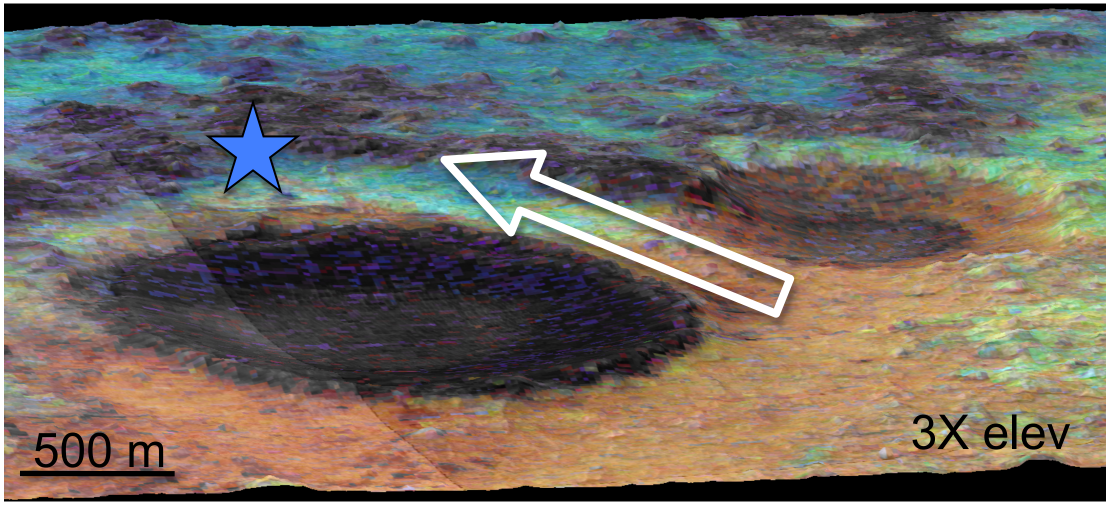
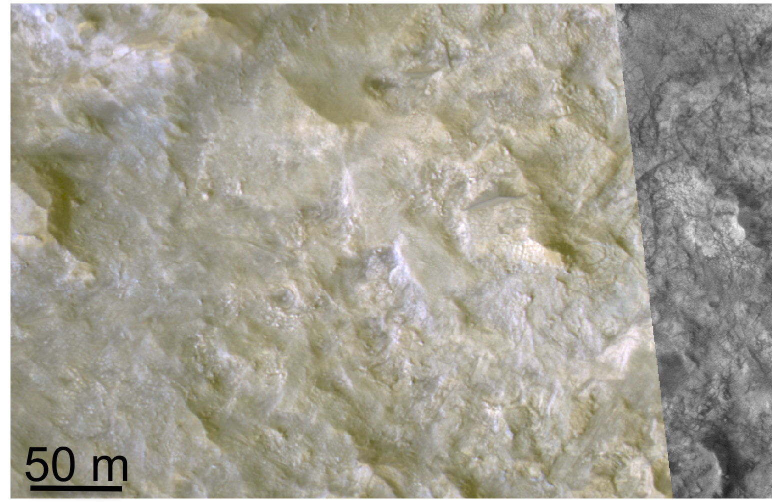
Stop 2: Transition Fe/Mg-phyllo to Al/Si phyllo





1. GEOLOGY	Image site with **Mastcam** to characterize geologic features across mineralogy transition from Fe/Mg-smectite unit to rocks high in Al/Si phyllosilicate/amorphous material; look for indication of aqueousand leaching processes; compare relative ages of Fe/Mg-smectite rocks with Al-phyllosilicate rocks.
2. MIN+CHEM	Confirm Al-phyllo/hydrated silica mineralogy using **ChemCam**, **CheMin**, and **APXS**; estimate abundance and homogeneity of phyllo/silica and other components; characterize C, H, N, O, P, S in clay-rich rocks using **SAM/APXS**; examine differences in mineralogy and chemistry from Fe/Mg-smectite rocks and Al-phyllosilicate rocks to assess changes in geochemical environment.
3. ORGANICS	Identify any differences in trapped organic compounds with **SAM**.
5. BIOSIG	Characterize differences in grains with **MAHLI** across mineralogy transition. Search for differences in organics and isotopes with **SAM**.
6. PRESERV	Search for sedimentary processes using **MAHLI**; identify changes in chemistry with **APXS** from older Fe/Mg-smectite to younger Al-phyllo/hydrated silica.

MSL Expectations for Mawrth Vallis

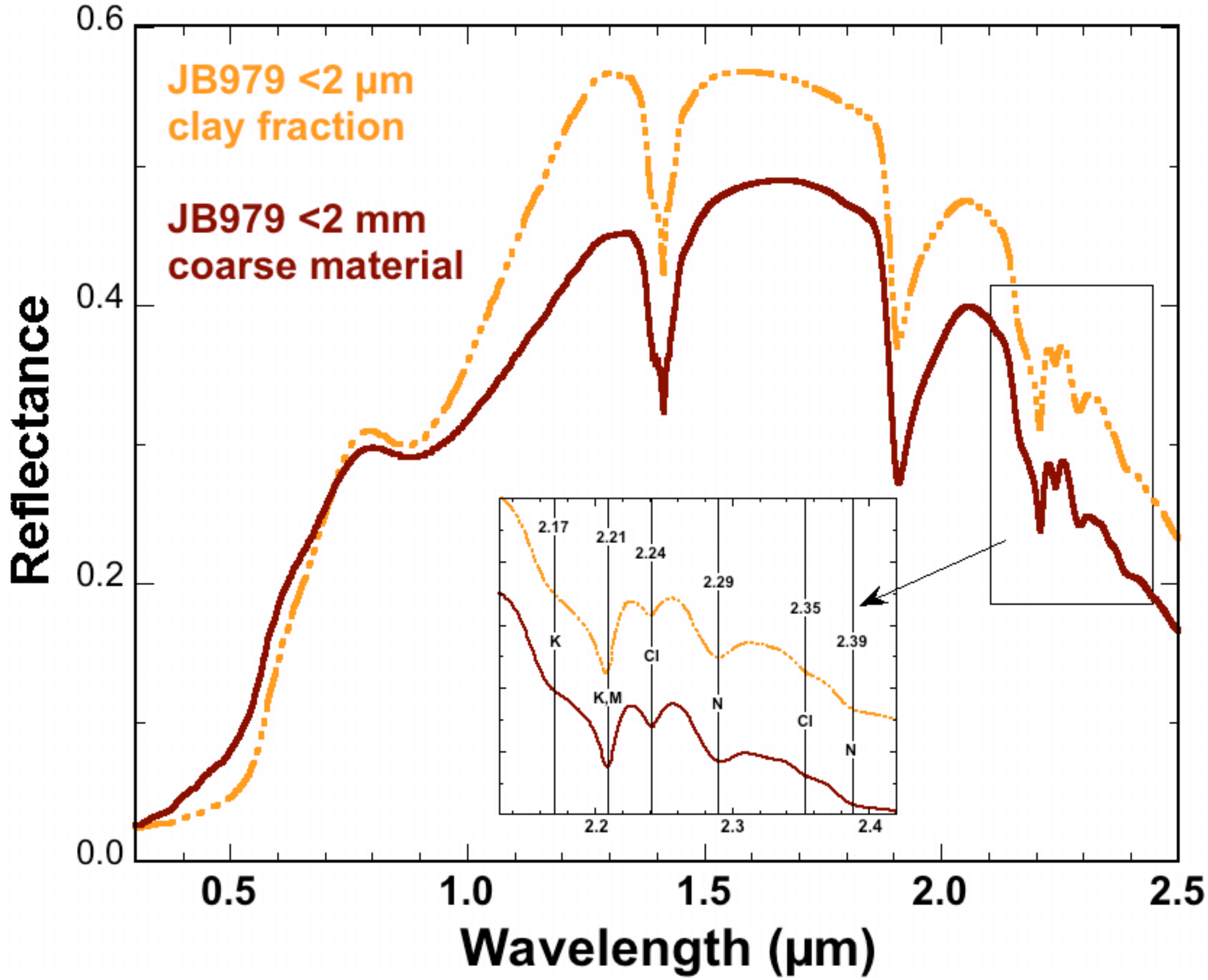
- Instruments on MSL can answer key questions about mineralogy and biosignatures at Mawrth Vallis:
  - CheMin and APXS will identify additional clay minerals associated with dominant smectites.
  - CheMin and APXS will address whether or not the “Fe^{2+}” phase in between the Al-phyllo and Fe/Mg-smectite units is in fact an Fe^{2+}-clay such as chlorite, or alternatively a collapsed smectite (á la Morris) or a completely different ferrous mineral e.g. olivine, siderite, melanterite.
  - CheMin and APXS will identify other minerals present in the clay-rich rocks that will assist in understanding formation mechanisms and potential habitability conditions.
- ChemCam, APXS and SAM will document changes in chemistry across transitions from ancient Fe/Mg-smectite-rich rocks to younger Al-phyllo/ hydrated silica.
- SAM will identify minor amounts of hydrocarbons, carbonates and biogenic minerals such as sulfide that could be trapped in the smectites.

CRISM-MSL Data Comparison

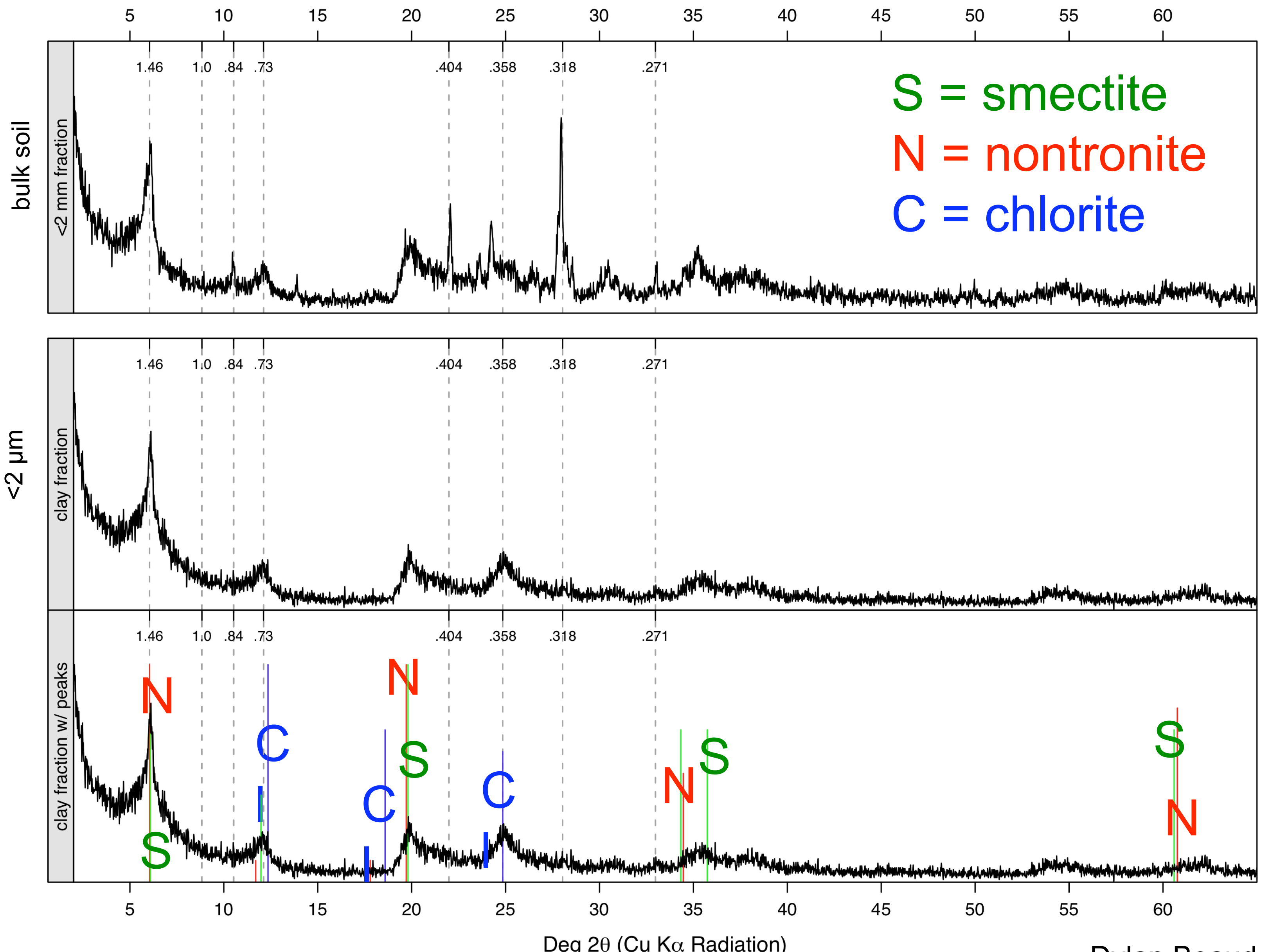
- Test instruments on northern California soils that contain multiple clay minerals:
- especially high in Fe/Mg-smectite and chlorite.
- VN reflectance – Janice Bishop
- XRD – Dylan Beaudette

- Test instruments on Antarctic sediments that contain multiple minerals (feldspar, pyroxene, quartz, clays) and organics:
- especially high in carbonate, some hydrocarbons and biogenic pyrite.
- VN reflectance – Janice Bishop
- XRD – Dave Blake
- SAM evolved gas analysis (EGA)– Heather Franz & Paul Mahaffy

VNIR Lab Reflectance: Northern CA pedogenic soils

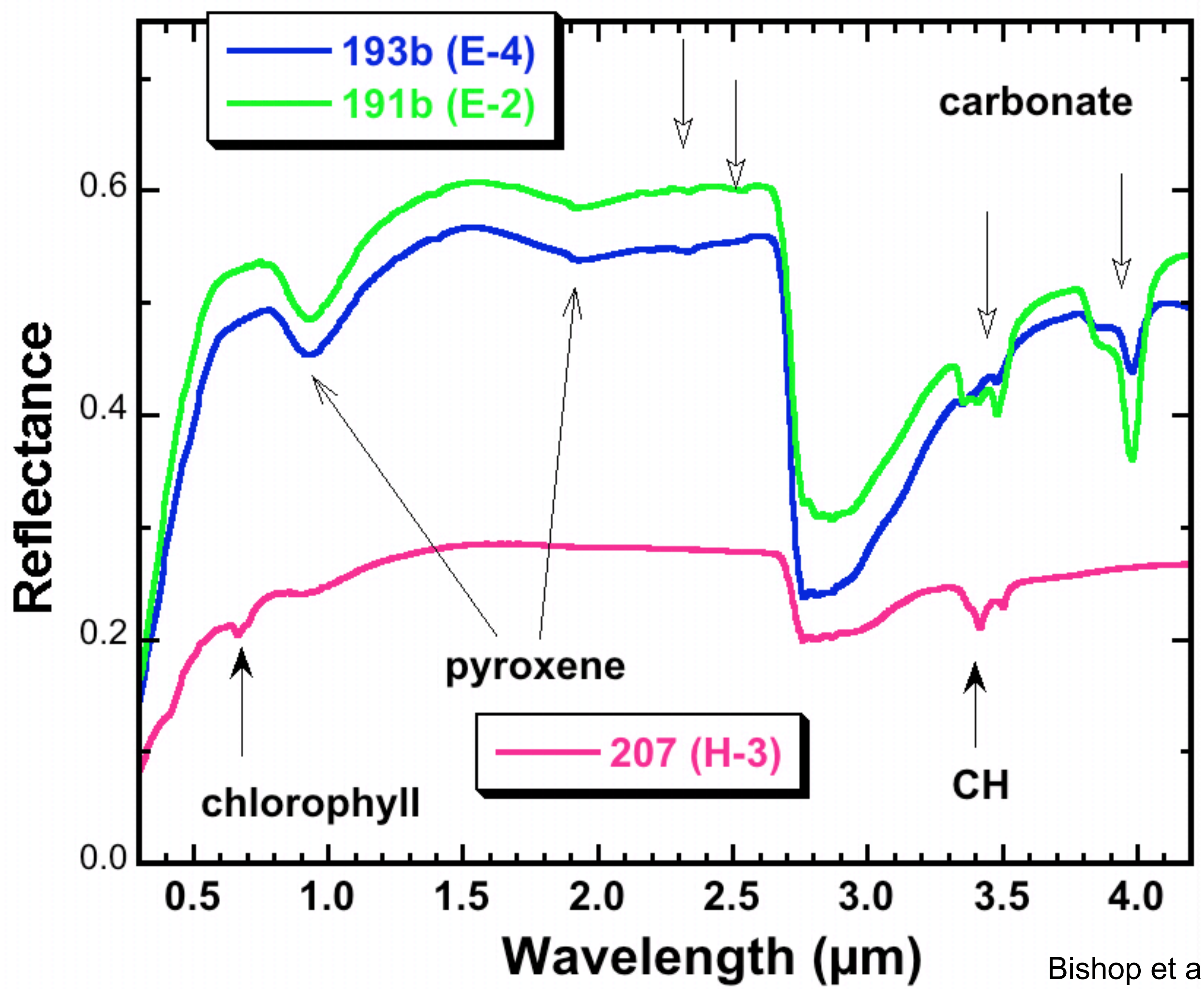


XRD: Northern CA pedogenic soils



Dylan Beaudette

VNIR Lab Reflectance: Lakebottom Sediments, Antarctic Dry Valleys



Bishop et al. (2001)GCA

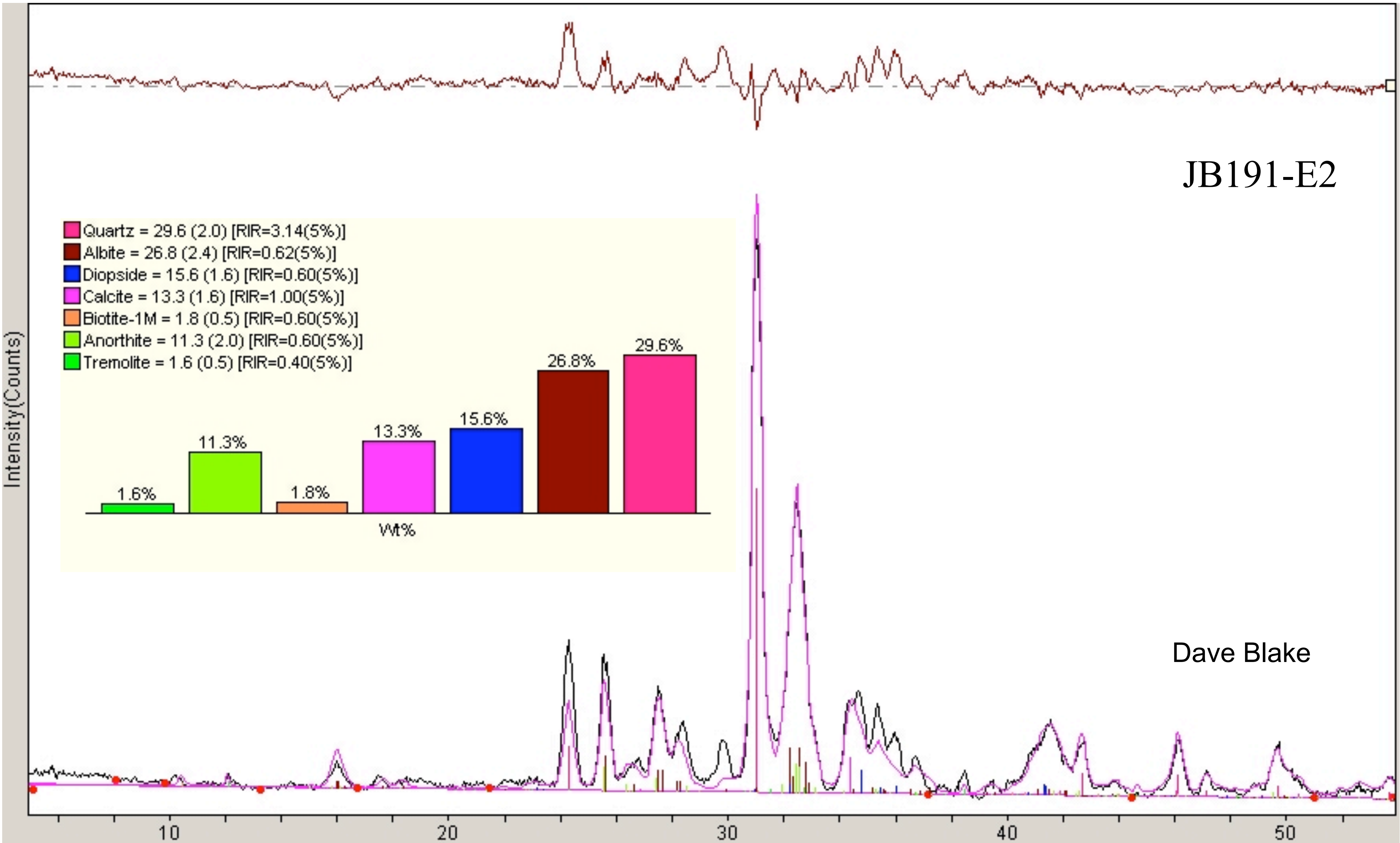
Chemistry: Antarctic Sediments
to compare with ChemCAM, APXS, SAM

Sample	SiO_2	Al_2O_3	FeO	MgO	CaO	P_2O_5
E-2	55.4	13.2	4.0	3.2	12.3	0.14
E-4	59.4	15.1	4.5	3.9	7.8	0.15
H-3	59.7	14.3	6.3	3.8	4.6	0.18

Sample	wt.%C_{in}	wt.%C_{org}	$\delta^{13}C$	$\delta^{15}N$	$\delta^{34}S$	Region
E-2	1.04	0.38	-20.4	3.2		oxic zone
E-4	0.34	0.14	-19.5	3.0		oxic zone
H-3	0.03	1.02	-26.3	-5.6	-18.6	anoxic zone

Bishop et al. (2001) GCA

XRD: Antarctic Sediments to compare with CheMin



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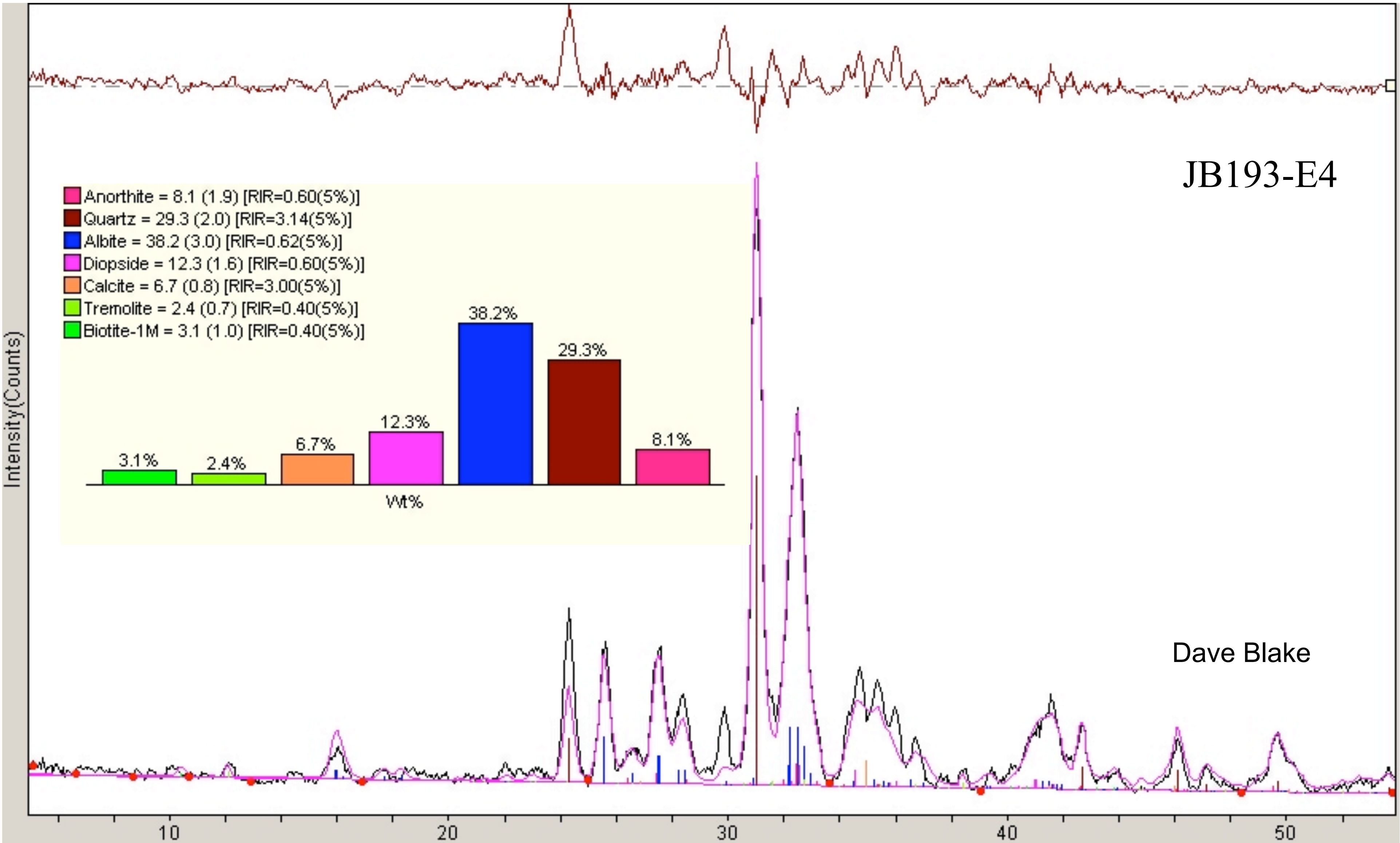

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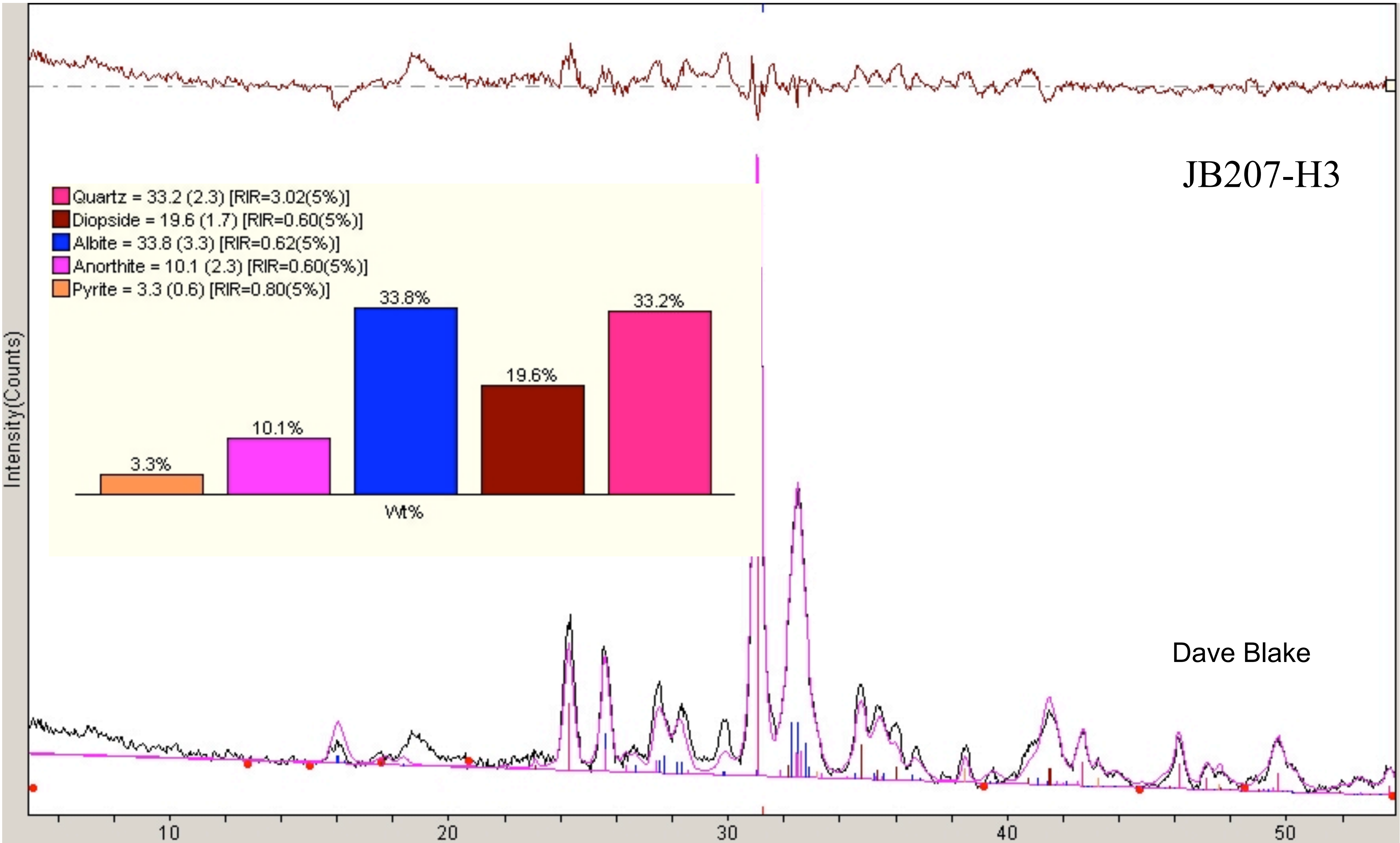
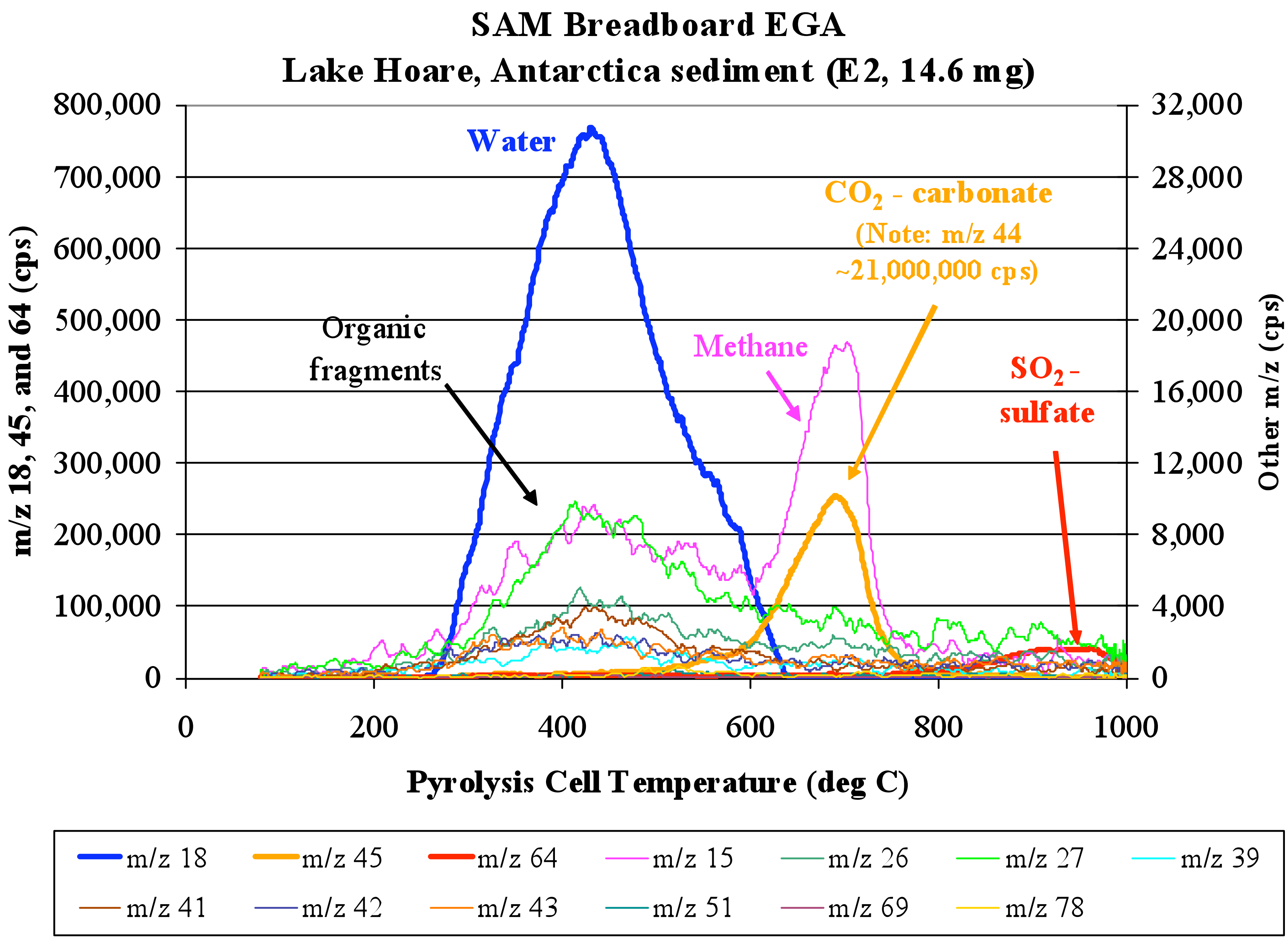
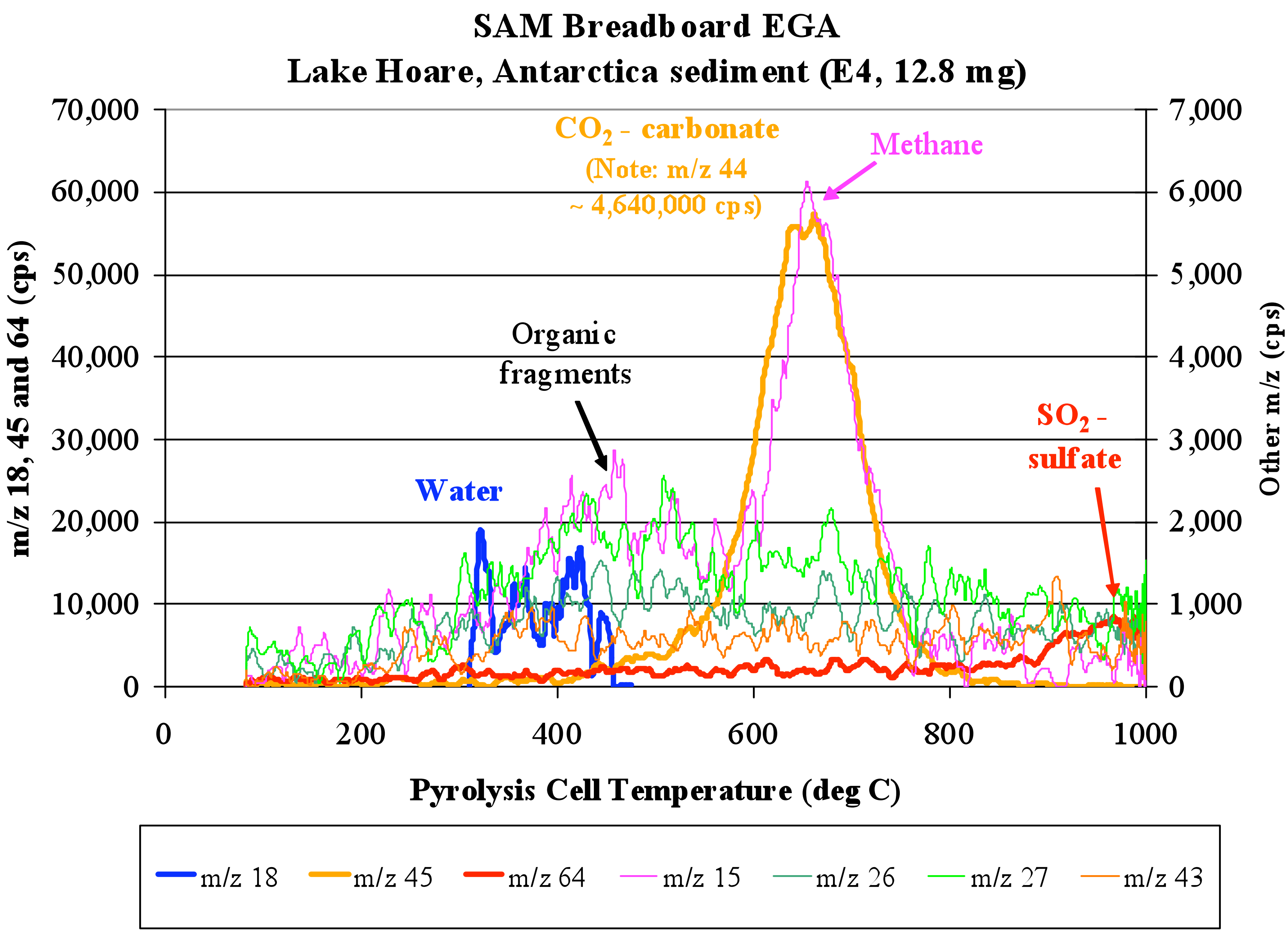




Analyst: Heather Franz



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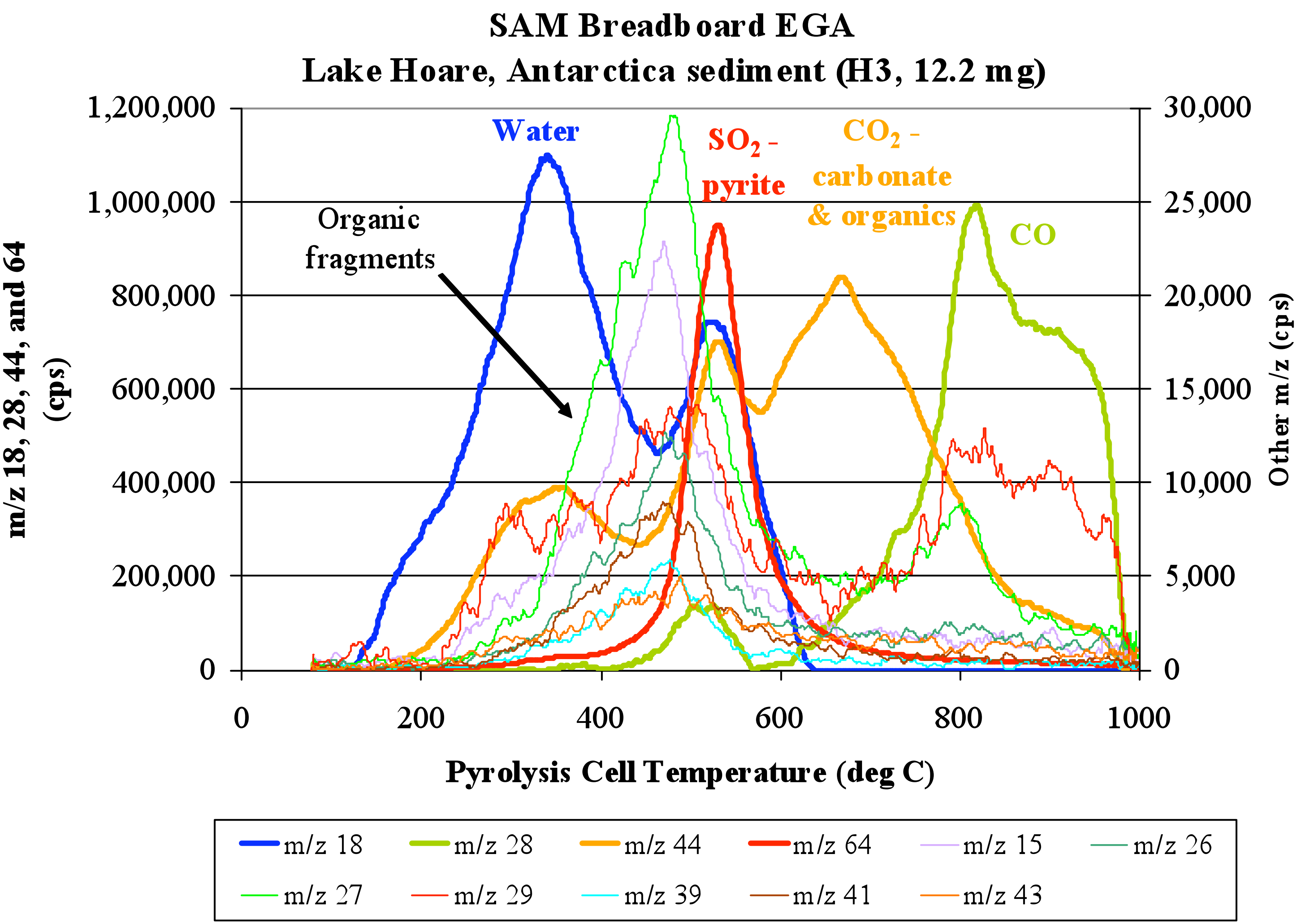

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